平成19年度生理研研究会　脳機能画像解析入門中級コース

11月20日 (火)

13:30 - 13:40 Opening remark

13:40 - 14:40 1 低周波ノイズの扱い

谷中久和･市川奈穂･牧陽子

14:40 - 15:40 2 Event-related designの最適化

村瀬未花･松本敦･間野陽子

15:40 - 16:00 *Coffee break*

16:00 - 17:00 3 共通項と特異項の抽出

米田英嗣･森戸勇介･佐々木章宏･佐野香織

17:00 - 18:00 4 主観･個人差への挑戦

出馬圭世･林正道

11月21日 (水)

9:00 - 10:30 5 Effective connectivity概説

河内山隆紀*･藤井猛　*㈱国際電気通信基礎技術研究所脳活動イメージングセンター

10:30 - 10:50 *Coffee break*

10:50 - 11:50 6 自由討論

11:50 - 12:00 Closing remark

平成19年度生理研研究会 「神経科学の道具としてのfMRI研究会」研究発表会

21-Nov

13:30 - 13:35 Opening remark

Innovative designs for fMRI studies

13:35 - 14:10 1 **Visual image reconstruction from human cortical activity by combination of multi-resolution local image decoders**

宮脇 陽一
(独) 情報通信研究機構、㈱国際電気通信基礎技術研究所脳情報研究所

14:10 - 14:45 2 **Sensing hand movement using visual and kinesthetic information**

羽倉 信宏
京都大学大学院人間･環境学研究科

14:45 - 15:00 *Coffee break 1F Reception Hall*

15:00 - 15:35 3 **An fMRI study using a group comparison: a case study on second language processing**

Hyeonjeong JEONG
東北大学加齢医学研究所脳機能開発研究分野

15:35 - 16:10 4 **Hemodynamic responses during learning of lexical-semantic and syntactic information in a miniature language**

Jutta L Mueller
Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany/National Institutes for Longevity Science

16:10 - 16:45 5 **Processing of infant-directed speech in parents: Experience, gender and individual dependency**

松田 佳尚
理化学研究所BSI言語発達研究チーム

16:45 - 17:00 *Coffee break 1F Reception Hall*

17:00 - 17:35 6 **Neural substrate of stress coping style as revealed by regression analysis of self-evaluated spontaneity during acting.**

関口 敦
東北大学加齢医学研究所脳機能開発研究分野

17:35 - 18:10 7 **自己顔評価における右側前頭前野の役割**

守田 知代
科学技術振興機構(JST/RISTEX)

18:30 - 20:30 Reception 1F Reception Hall

22-Nov

Innovative techniques for fMRI studies

9:00 - 9:35 8 Probing functional specificity through neuronal interaction in fMRI response

成 烈完
濱野生命科学研究財団 小川脳機能研究所

9:35 - 10:10 9 Analyzing Functional MRI Time-Course Using a Wavelet-Based Approach (Activelets)

Ildar KHALIDOV
RIKEN Brain Science Institutes,Tokyo,Japan/EPFL, Lausanne, Switzerland

10:10 - 10:45 10 Akaike causality for fMRI Studies

WONG Kin Foon Kevin
科学技術振興機構 (JST/RISTEX)

10:45 - 11:00 *Coffee break 1F Reception Hall*

11:00 - 11:35 11 Influence of visual saliency on cortical activities: a functional MRI study in awake macaque monkeys

郷田直一
生理学研究所 感覚認知情報部門

11:35 - 12:10 12 Dynamic switching of thalamocortical network in association with transition between REM and NREM sleep

小池 耕彦
(独)情報通信研究機構 未来ICT研究センター CREST脳機能イメージングチーム

12:10 - 12:20 Closing remark

1. Visual image reconstruction from human cortical activity by combination of multi-resolution local image decoders

Yoichi Miyawaki, Hajime Uchida, Okito Yamashita, Masa-aki Sato, Yusuke Morito, Hiroki Tanabe, Norihiro Sadato, Yukiyasu Kamitani
NiCT,ATR CNS,NAIST,NIPS

Pattern analysis of fMRI signals can accurately predict the presented visual features (e.g., orientation). As previous approach focused on a single dimension of visual features, it cannot reveal a visual image from the cortical activity evoked by an arbitrary visual stimulus. Here we show that arbitrary visual images that a subject is seeing can be reconstructed from fMRI signals of the early visual cortex by combining local image decoders that predict local image contrast of multiple spatial scales.

We performed fMRI scans (3 T, 3 mm^3 voxels) while subjects viewed a sequence of random pattern images consisting of small flickering checkerboard patches. A set of local image decoders were trained to predict the mean contrast of local image segments of multiple resolutions. The trained decoders were then combined so as to minimize the reconstruction error using the training data. In separate sessions, we measured fMRI data evoked by geometric shape images, which were not used to train the decoders, to test if the combined decoder generalizes to the novel images.

The combined decoder showed accurate reconstruction performance, revealing sharp geometric shapes. The decoders of multiple resolutions were complementary over eccentricity and outperformed a single resolution decoder. Our algorithm automatically found retinotopic voxels relevant for the reconstruction without conventional mapping experiments.

These results suggest that the validity of combinatorial representation of visual images in the early visual cortex. Our approach extends previous decoding technique to deal with high dimensional nature of human perceptual space based on the representation model.

2. Sensing hand movement using visual and kinesthetic information

Nobuhiro Hagura
Kyoto University, JSPS

Neuroimaging techniques, in particular functional magnetic resonance imaging (fMRI), allow us to infer the neuronal mechanisms underlying human cognitive/perceptual function. In the basic conventional analysis, brain activity (hemodynamic response) that occurs in a certain time epoch is associated with the cognitive/perceptual function assumed to take place in that time epoch. Further analyses can be performed to validate the results obtained in this basic analysis. Testing the correlation between the behavioral measure (ex. perceptual ratings, reaction times) and the strength of the brain activity can confirm the association between the detected brain region and that particular function (correlation analysis). Functional connectivity analysis may elucidate the inter-regional communication between the detected region and the other brain regions, which may be important in achieving that function.

In my talk, I will introduce our recent studies where the above methods are used to investigate the brain network involved in the multisensory processing of visual and kinesthetic information of hand. Firstly, I will introduce our study which demonstrated the role of posterior parietal cortex in aligning the hand position signaled from visual and kinesthetic information. Second, I will introduce our study that showed the participation of the left cerebellum in aligning the velocity of directionally concordant visual and kinesthetic information of hand movement, and the occurrence of cerebro-cerebellar interaction during that process.

3. An fMRI study using a group comparison: a case study on second language processing

Hyeonjeong JEONG
1. Japan Society for the Promotion of Science,
2. Department of Functional Brain Imaging, IDAC, Tohoku University

In the neuroimaging literature, the age of second language (L2) acquisition, the level of L2 proficiency, and the amount of exposure are major determinants of whether and how cortical representation differs between L1 and L2. Very limited studies (e.g., Jeong et al., 2007) have attempted to examine how linguistic similarities and differences between L1 and L2 affect brain activation during L2 processing, although second language acquisition literature has documented their important roles in L2 acquisition. In this study, we conducted an fMRI study on L1 and L2 sentence comprehension tasks for two different L1 (i.e., Korean and Chinese) groups who learned two L2s (i.e., English and Japanese). We present data from 18 Korean and 12 Chinese subjects who performed sentence comprehension tasks in each L1 (Korean or Chinese) and two L2s (English and Japanese). These two groups showed similar L2 learning backgrounds, age of L2 acquisition, the amount of L2 exposure, and L2 proficiency levels. Nonetheless, differential brain activation patterns were observed between the Korean and Chinese groups. During the English relative to L1 sentence comprehension tasks, the Korean group showed significantly greater activation in the bilateral posterior superior temporal gyrus, left inferior frontal gyrus, right inferior frontal gyrus, and right cerebellum than the Chinese group. In contrast, during the Japanese relative to L1 sentence comprehension tasks, the Chinese group showed significantly greater activation in the anterior portion of superior temporal gyrus than the Korean group. The results demonstrated that the location of the L2-L1 processing-induced cortical activation varies between different L1-L2 pairs.

4. Hemodynamic responses during learning of lexical-semantic and syntactic information in a miniature language

Jutta L. Mueller
Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany
National Institute for Longevity Sciences

The present study used the blood-oxygen dependent (BOLD) fMRI technique to investigate brain correlates of lexical semantic and syntactic processing and learning in a second language. In order to capture learning related changes in the BOLD signal we used a miniature version of Japanese which participants learnt partly before and partly during fMRI scanning. During scanning familiar sentences, sentences containing new words and sentences containing new word order were presented in conjunction with pictorial representations of their meaning. With regard to processing sentences with new syntactic or semantic information compared to familiar sentences we found strikingly overlapping patterns of brain activation. No region was exclusively activated for the processing of new syntactic structures whereas the bilateral caudate nuclei and the left fusiform gyrus were active only in the lexical-semantic condition. Activation that was parametrically modulated by the amount of learning as reflected in individual learning curves was found only in the lexical-semantic condition. Specifically, left inferior frontal gyrus, left middle temporal gyrus and left anterior fusiform/parahippocampal areas were related to the behavioural learning measure. The results point to shared mechanisms for the processing of new and difficult sentences but also to different learning related dynamics in syntactic and lexical-semantic learning.

5. Processing of infant-directed speech in parents: Experience, gender and individual dependency

Yoshi-Taka Matsuda
Lab for Language Development, Brain Science Institute, RIKEN

Adults are known to use a special style of speech when they talk to infants. The properties of infant-directed speech (IDS) include prosodic and lexical modifications. While these linguistic components are independent and considered to be lateralized in opposite hemispheres (i.e., prosodic processing in the right hemisphere and lexical processing in the left), both are functionally connected in terms of IDS and may share neural processing during the perception and production in experience-, gender- and/or individual-dependent manners. This hypothesis was tested with Japanese parents (n=35, 20 mothers), who have had their first babies within one year, and non-parents (n=30, 15 males) using fMRI (Varian 4T MRI system) with an event-related design. IDS effects were determined by measuring differential activity when the subjects discriminated auditorily presented IDS stimuli from adult-directed speech (ADS) stimuli, selectively attending to either the prosody or lexicon, and foll owed by the mental rehearsal of the percept. The following four results were revealed in the random-effects analysis of multiple comparisons with GLM. (1) Mothers showed significant activation to both prosodic and lexical IDS in the classical language areas. (2) Fathers and non-parents did not show these activation. (3) Mothers had a correlation between brain activities to IDS and extraversion scores of psychological index, which reflected individual difference of social personality trait in IDS processing. (4) These activations and correlation disappeared when their children developed to school ages. These results suggest that mothers process IDS in a use-dependent manner.

6. Neural substrate of stress coping style as revealed by regression analysis of self-evaluated spontaneity during acting.

関口敦
東北大学加齢医学研究所脳機能開発研究分野

The way to cope with a stressful situation differs across individuals and occasions. In this fMRI study, we examined the top-down process of an adaptive stress coping styles. We designed the stress coping styles into a two factorial design, incorporating a direction of demand (Self vs. Other) and a direction of view (Prospective vs. Retrospective). We were particularly interested in the Self Prospective style as an adaptive coping style.

Thirty-two healthy subjects performed an acting task. Each subject was presented with a picture of a stressful situation in which an actor comments (presented in a balloon) to the subject on the situation. With a delay of two seconds, a possible verbal response to the comment in one of the four stress coping patterns (i.e., Self Prospective, Self Retrospective, Other Prospective and Other Retrospective) was presented, and the subject was required to act the protagonist of the situation by responding as presented.

After MRI measurement, each subject self-evaluated how naturally he/she could act (Spontaneity scores) for each response. Given that the stress coping styles was the spontaneous response to the situation, we assumed that the top-down process related to each coping styles was correlated with the Spontaneity scores during act.

A significant negative correlation between the Spontaneity scores and neural responses for the Self Prospective conditions was observed in the right anterior temporal lobe. The results indicated the advantage of the low response in this region to the stressful situation for adaptive social behavior.

7. 自己顔評価における右側前頭前野の役割

守田知代
科学技術振興機構（JST/RISTEX）

自分の顔など自己像を与えられると、それに対して自己評価的な認知活動が生じ、特に自己の中にある基準とのズレが大きい場合には、羞恥心などのネガティブな情動が生じると言われている。本研究では、自己評価プロセスに関わる神経基盤を明らかにするために以下のような fMRI 実験をおこなった。被験者には自己顔および未知人物の顔を呈示し、それらの写真写りを評価しているときの脳活動を計測した。その結果、他者顔の評価時に比べて自己顔の評価時には、右側前頭前野領域において有意な活動増加が見られた。その中でも右側中心前溝では、自己認知と深く関連する自己意識の個人特性を反映した活動が見られた。また、それよりも前方に位置する右側下前頭回の活動は、自己評価の結果生じる羞恥心の強度と相関することが示された。これらの結果より、自己顔の評価に関わる右側前頭前野領域において異なる機能的役割をもつ領域の存在が示された。

8. Probing functional specificity through neuronal interaction in fMRI response

成 烈完
濱野生命科学研究財団 小川脳機能研究所

It is very difficult by disentangling an functional MRI (fMRI) response to separate neuronal circuits contributing to the fMRI response in an area when a stimulus has more than two kinds of specific information and those information are represented into different neuronal circuits each other. Areas in the visual ventral pathway show common activation to stimuli belonging to different object categories while some of them have their preferred categories. To investigate functional specificity in those areas we in this study used a paired stimulus paradigm which can induce a refractory suppression in fMRI. The suppression phenomenon is that the response to the second stimulus is suppressed if two inputs to an area are processed in the same way when the stimuli arrive at the site in short succession.

9. Analyzing Functional MRI Time-Course Using a Wavelet-Based Approach (Activelets)

Ildar Khalidov, Dimitri Van De Ville, Jalal Fadili, Michael Unser and Kang Cheng
RIKEN Brain Science Institute, Japan
EPFL, Switzerland

Over recent years, functional magnetic resonance imaging (fMRI) has become a key modality in imaging human brain function. The blood-oxygenation-level-dependent (BOLD) signal, which originates from an overcompensation in oxygenated hemoglobine following neuronal activity by the neurovascular system, can be measured and localized using fast acquisition of T2* MRI volumes. The analysis of these large spatio-temporal datasets is difficult due to noise, measurement artifacts, and the variability of the BOLD response.

The classical approach puts forward a linear model to explain a voxel's time course. The modeled BOLD response is the convolution of the haemodynamic response function (HRF) with the stimulus function, which can be a train of boxcar functions (block-based paradigm) or Dirac delta-functions (event-related paradigm). A widely used model for the HRF is the sum of two gamma-functions. Finally, voxels are declared as activated based on the results of statistical hypothesis testing.

In this work, we concentrate on the event-related setting. Our activelet approach relies on two key ideas. First, a specially-designed wavelet basis allows concentration of the activity-related signal energy on a small number of decomposition coefficients. Second, a fast sparse-solution search algorithm is used to determine the position and the value of these coefficients. Our approach does not use any a priori knowledge on the stimulus onset times; as a consequence, it is robust to the variability of the BOLD response. Compared to the classical algorithm, the activelet method has potential in a wider class of neuroscience applications where the exact stimulus times are not known and should be estimated directly from the data.

10. Akaike causality for fMRI studies

KFK Wong[1], Tohru Ozaki[1,2]
科学技術振興機構 (JST/RISTEX) [1], 統計数理研究所 [2]

Intrinsic connection between brain regions has been an important issue in fMRI study. Yet the majority neglects the direction of connectivity while discussing the influence that one brain region exerts on another. Directional connectivity can be obtained only by taking the information along the time into consideration, is applying statistical time series model. With aids of multivariate autoregressive model, directional connectivity can be obtained using causality technique, for instance, the Akaike causality. Nonetheless the issue of instantaneous causality comes up in connectivity study of fMRI. The primary reason is the low sampling rate of fMRI images. Such sampling rate is perfect for observing HRF but insufficient to detect a faster response at a voxel over the others. Interpreting causality becomes uneasy when number of regions of interest increases.

In this contribution we present a new approach of explaining instantaneous causality in multivariate time series by the class of state space model. Every single time series can be divided into two noise-driven processes, a common process shared among multivariate time series and a specific process refining the common process. Using Akaike causality theory, causality among brain regions are quantified over the spectral domain. We will illustrate the method with applications to two sets of fMRI data, and explore the potential of state space modeling for fMRI data analysis.

11. Influence of visual saliency on cortical activities: a functional MRI study in awake macaque monkeys

Naokazu Goda
生理学研究所　感覚認知情報部門

Our visual system can rapidly and effortlessly detect a salient object in a cluttered visual scene. Recent electrophysiological studies in monkeys suggest that such an efficient detection of the salient object involves processing in multiple areas in frontal and parietal cortices, as well as competitive interaction in retinotopic areas in occipital cortex. To clarify the whole picture of this distributed network, we measured the influence of the visual saliency on the activities in various cortical regions by using functional MRI in the awake macaque monkeys. We used an array stimulus containing eight disks; in some arrays one of the disks in the left or right hemifield was unique in color (left-singleton / right-singleton), in others all were identical (no-singleton). We presented these different singleton stimuli to the monkeys during a fixation task in a block design. We found that the presence of the pop-out, salient singleton in the array enhanced BOLD responses in V2/V3, V4, MT and LIP. The enhancement was observed in the hemisphere contralateral to the location of the singleton. Interestingly, we also found a strong response enhancement with the contralateral bias on the posterior bank of the superior temporal sulcus (STS), which was located anterior to MT and medial to TEO. This STS region has not been explored by electrohysiological recordings. Our findings shed new light on the neural system involved in the detection of the salient object.

12. Dynamic switching of thalamocortical network in association with transition between REM and NREM sleep

Takahik Koike, Shigeyuki Kan, Masaya Misaki, & Satoru Miyauchi
CREST brain function imaging team, KARC, NICT.

In recent years, increased attention has been directed at investigating spontaneous brain activities; examination of spontaneous BOLD activity has made clear that several brain regions form a functionally-connected 'resting-state network' during wakefulness without goal-directed tasks.

Another attention has been paid to brain activities during sleep.

Although there seems to be also no explicit goal-directed tasks during human REM/NREM sleep state, several recent studies suggest that spontaneous brain activities during sleep are associated with important brain functions such as memory consolidation.

Therefore, considering functionally-connected brain network associated with human REM/NREM sleep may be helpful to investigate sleep-stage-related brain functions.

To investigate characteristics of spontaneous networks linked to human sleep states, we used fMRI with simultaneous polysomnographic recording, and examined functional connectivity between thalamus and other cortical areas, using a technique with Spearman's rank-correlation coefficient between the BOLD signals.

We found that a set of regions, including DLPFC, anterior cingulate and hippocampus, showed significantly increased connectivity to thalamus during NREM sleep period (sleep stage 3/4).

In contrast, during REM sleep which is usually linked to vivid dreaming, we found a thalamocortical network including visual cortices, hippocampus and primary motor area.

In addition, only during REM sleep, we found a significant functional connectivity between the thalamus and the posterior cingulate cortex, precuneus, and inferior temporal gyrus; these regions are known as a part of 'default network'.

Our findings show that thalamocortical network switches in association with transition of sleep states between NREM and REM, and suggest that identifying functionally-connected brain network using correlation coefficient between BOLD signals is a useful tool for exploring brain functions of NREM and REM sleep.